FNU FIJI NATIONAL UNIVERSITY

COLLEGE OF ENGINEERING, SCIENCE AND TECHNOLOGY

<u>School of Electrical & Electronics Engineering</u>

<u>Bachelor of Engineering (Honours) (Electrical & Electronics Engineering)</u>

EEB831 – Digital Signal Processing

FINAL EXAMINATION

Semester 1, 2018

Date: As per Exam Time Table

Time: As per Exam Time Table (3 hours)

Venue: As per Exam Timetable

<u>Instructions to Students</u>

1. You are allowed an extra ten (10) minutes of reading time during which you are NOT allowed to write.
2. Attempt ALL questions in this examination booklet
3. Write your answers in the answer booklet provided.
4. Write your Student ID number on each page used.
5. Begin each Section on a fresh page and use both sides of the answer sheet.
6. You may use calculators provided they are non-programmable.
7. Clearly number the questions in your answer paper in their correct sequence and write legibly. Show all working.
8. Attach any extra sheets used to your answer booklet securely with the string provided.

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Question 1 **[15 marks]**

a) Briefly explain the terms sampling, sampling theorem, aliasing, quantization, quantization error, and coding with respect to the process of analog to digital conversion. [8 marks]

b) Consider the analog signal $x_a(t) = 1.3\cos(2360\pi t) - 1.5\sin(5710\pi t) - 5.4\cos(13200\pi t)$.

   i. Determine the Nyquist rate for the signal. [2 marks]

   ii. Determine the resulting discrete-time signal and the frequencies present if the signal is sampled at 5700 Hz? [5 marks]

Question 2 **[12 marks]**

a) Consider the finite signal $x[n] = \begin{cases} (-2)^{n+1} n & ; \text{ for } n = -1,0,1,2 \\ 0 & ; \text{ otherwise} \end{cases}$

Also consider its periodic repetition $y[n] = \sum_{k=-\infty}^{\infty} x[n+9k]$. Compute the energy and power of both $x[n]$ and $y[n]$. [5 marks]

b) Given the signal $x(n) = \begin{cases} |-2n|-5, & -3 \le n < 4 \\ 0, & \textit{otherwise} \end{cases}$

   i. Represent $x(n)$ using sequence representation. [2 marks]

   ii. $y(n) = \sum_{-\infty}^{+\infty} x(k) = x(n-4) + x(n-2) + x(n) + x(n+2) + x(n+4) + x(n+6) + ...$ [5 marks]

Question 3 **[7 marks]**

a) Determine the one-sided z-transform of the signal $x_1(n) = x(n+2)$ given $x(n) = 1.17^n u(n)$.

[4 marks]

b) A linear time-invariant system is characterized by the system function $H(z) = \frac{1.5}{1-0.78z^{-1}} - \frac{2.1}{1+2.83z^{-1}}$. Specify the ROC of $H(z)$ and determine $h(n)$ so that the system is stable. Is the resulting system causal, anti-causal or non-causal? [3 marks]

Please Turn Over

Question 4 **[22 marks]**

Consider the FIR filter $y(n) = 0.47y(n-1) - 0.73x(n)$.

a) Compute and sketch its magnitude and phase response for $-2\pi \le w \le 2\pi$. *(Note: Plot the responses in the solution sheet provided).* [9 marks]

b) Determine the transient and steady state response of the system when the input signal is $x(n) = 2.5\cos(\pi n/4)\,u(n)$. [13 marks]

Question 5 **[12 marks]**

A two-pole lowpass filter has the system function $H(z) = \dfrac{b_0}{(1-pz^{-1})^2}$. Determine the values of center of b_0 and p such that the frequency response $H(w)$ satisfies the conditions $H(\pi) = 1$ and $\left|H\left(\dfrac{\pi}{3}\right)\right| = \dfrac{2}{9}$.

Question 6 **[12 marks]**

Using the Kaiser window, design a bandpass digital filter with the following specifications:

$f_s = 60$ kHz, $f_{sa} = 7$ kHz, $f_{pa} = 8$ kHz, $f_{pb} = 28$ kHz, $f_{sb} = 30$ kHz, $A_{pass} = 0.35$ dB, $A_{stop} = 50$ dB.

[12 marks]

Question 7 **[20 marks]**

a) Using a highpass analog 1st order filter, design a highpass digital filter operating at a rate of 5 kHz such that it has a gain of $A_c = 0.38$ dB at 1.75 kHz. [10 marks]

b) Draw the canonical form realization of the filter $H(z) = \dfrac{3 + 2z^{-1} - 2.8z^{-4}}{1 - 0.3z^{-1} + 0.5z^{-3} - 0.3z^{-4}}$ and determine its sample processing algorithm. [10 marks]

Please Turn Over

Given below is the z-transform table.

Signal, $x(n)$	z-Transform, $X(z)$	ROC
$\delta(n)$	1	All z
$u(n)$	$\frac{1}{1-z^{-1}}$	$\lvert z\rvert >1$
$-a^n u(-n-1)$	$\frac{1}{1-az^{-1}}$	$\lvert z\rvert < \lvert a\rvert$
$-na^n u(-n-1)$	$\frac{az^{-1}}{(1-az^{-1})^2}$	$\lvert z\rvert < \lvert a\rvert$
$(\cos w_0 n)\, u(n)$	$\frac{1-z^{-1}\cos w_0}{1-2z^{-1}\cos w_0 + z^{-2}}$	$\lvert z\rvert >1$
$(\sin w_0 n)\, u(n)$	$\frac{z^{-1}\sin w_0}{1-2z^{-1}\cos w_0 + z^{-2}}$	$\lvert z\rvert >1$

Equations:

$$Z^{+}\{x(n+k)\} = z^{k}\left[X^{+}(z) - \sum_{n=0}^{k-1} x(n) z^{-n}\right]$$

Analog highpass filter: $H_a(s) = \frac{s}{s+\alpha}$

Bandpass filter: $d(k) = \frac{\sin(w_b k) - \sin(w_a k)}{\pi k}$

Kaiser Window: $w(n) = \frac{I_0(\alpha\sqrt{n(2M-n)}/M)}{I_0(\alpha)}$

$$\text{Shape parameter } \alpha = \begin{cases} 0.1102(A-8.7), & \text{if } A \geq 50 \\ 0.5842(A-21)^{0.4} + 0.07886(A-21), & \text{if } 21 < A < 50 \\ 0, & \text{if } A \leq 21 \end{cases}$$

$$\text{Factor } D = \begin{cases} \frac{A-7.95}{14.36}, & \text{if } A > 21 \\ 0.922, & \text{if } A \leq 21 \end{cases}$$

THE END

ALL THE BEST FOR THE EXAMINATION

Solution sheet for graph of Question 4(a). To be attached to your answer booklet.